TRANSPORT and ROAD
RESEARCH LABORATORY

Department of the Environment
Department of Transport

TRRL LABORATORY REPORT 1118

AUTOMATIC SPEED WARNING SIGN – HAMPSHIRE TRIALS

by

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Crowthorne, Berkshire
1984
ISSN 0305–1293

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Ownership of the Transport Research Laboratory was transferred from the Department of Transport to a subsidiary of the Transport Research Foundation on 1st April 1996.

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ABSTRACT

Four automatic speed warning signs were installed in Hampshire as a joint experiment by TRRL and the County Council. The signs were located at the villages of West Meon and Droxford in the Meon Valley (A32), just within 30 mile/h speed limit zones, and near Middle Wallop Army Base (A343), where only the 60 mile/h national speed limit for single-carriageway roads applied. Vehicles exceeding a pre-set trigger speed activated the signs which then displayed 'SLOW DOWN PLEASE', Later the message was amended to 'SLOW DOWN 30' ('45' at Middle Wallop). Speed measurements, supported by control data, were made at regular time intervals before and after installation, at the signs and in the villages.

Speed reductions in the centre of the villages at West Meon and Droxford were very small, but some drivers appeared to be reacting to the presence of the signs by slowing down before reaching them. The data indicate an overall reduction in injury accidents of 52 per cent, although this result is not statistically significant. It may be that the signs alert drivers to be more attentive to the road ahead, even if they do not slow down.

At Middle Wallop, the sign did not have an effect on speeds and there was no change in injury accidents.

1. INTRODUCTION

A 'secret' warning sign which comes on to give a relevant message only to the individual driver who requires it, might be expected to have a greater effect than a permanent sign which addresses itself to the driving population as a whole. Road safety research at TRRL has been directed at two specific devices based on this premise; the Speed Warning sign and the Close-Following Warning sign. This report is concerned with an evaluation of the Speed Warning sign, which detects the speed of a vehicle and activates a 'secret' sign if that speed is above a pre-set trigger speed. The signs were evaluated in terms of reduction in speeds and their effect on injury accidents.

Officers of the Hampshire County Council wished to try these signs at the villages of West Meon and Droxford in the Meon Valley, where more conventional accident countermeasures had not been entirely successful. It was agreed that signs should be installed at these locations in a co-operative experiment with TRRL. Hampshire County Council staff arranged for the purchase and installation of the signs, for the measurement of the speed of vehicles and the collection of accident data. TRRL advised on the data collection, analysed the results and provided part of the funding. It was intended that four signs should be installed on the A32 within 30 mile/h speed limit zones, one on each approach (northbound and southbound) to both West Meon and Droxford. However a suitable location was not available for a sign on the southbound approach to Droxford and this sign was re-deployed on the A343, about 0.5 km before the entrance to Middle Wallop Army Air Base. This latter site represented a small community on a fast main road, where a speed limit could not be justified by normal criteria (only the 60 mile/h national speed limit applied).

Similar signs have been used on three previous occasions in this country, by the Merseyside Police Force, by the Sussex Police Force (Eagle and Homans, 1976) and by the Gwent County Council, who temporarily installed signs on the M4 in connection with road works. In these cases, the signs were not supported by enforcement.

Two studies in the United States (Hunter et al, 1976; Koziol and Hengert, 1977) have also been reported and both these, and the UK work, have shown reductions in the speeds of vehicles when the automatic signs have been in operation. In most cases, however, the reduction in mean speed was small, although it was statistically significant. Each sign was triggered by a threshold speed which was above the statutory speed limit and was seen by a minority of all drivers passing it. This would in turn reduce the effect on the mean speed. A more sensitive measure was to consider the change in the proportion of drivers exceeding a certain speed at the monitor point, both before and after the sign was brought into use. The largest effect recorded was in the study at Fernhurst, Sussex where the proportion of vehicles exceeding 35 mile/h (56 km/h – the trigger speed of the sign) in a 30 mile/h (48 km/h) limit was halved when the sign was in operation. Noteworthy in this case was the message displayed when the sign was triggered – POLICE YOU ARE SPEEDING. The Police did not take any enforcement action in connection with the sign at Fernhurst, but the implication that the message was from them and directed at a driver who was exceeding a statutory speed limit, may in part account for its effectiveness. Perhaps most surprising is the fact that 20 per cent of all drivers still exceeded 35 mile/h (56 km/h) at the monitor point 150 yds (137 metres) beyond the sign, even with the sign in operation. Comparisons between these earlier studies are difficult because each involved different speed limits, trigger speeds for signs and sign messages, quite apart from the signs being installed on roads with different physical and flow characteristics. None of the previous studies reported a statistically significant reduction in accidents.

2. SIGNS AND INSTALLATION

2.1 The signs

The signs in Hampshire were fully automatic in operation (Fig 1 shows the layout of a typical site). The speed of every vehicle approaching the sign was measured as it passed over a pair of inductive loop detectors buried beneath the road surface and this speed was compared electronically with a pre-set trigger speed. The sign was illuminated for any vehicle whose speed exceeded the trigger speed. When not operating the sign was blank, with no clue as to its purpose. In appearance (Plate 1), it closely resembled a motorway matrix signal and was similarly fitted with amber lights in each corner. When the sign was activated, these amber lights were illuminated alternately in pairs, above and below the sign message, and flashed on and off at twice the rate used on motorways. This faster rate was selected (between 120 and 144 times per minute) to attract attention to the sign quickly, since it was only illuminated for three seconds (see below).

The initial message was SLOW DOWN PLEASE (Plate 2). Each letter of the message was formed by a number of pin-points of light individually supplied through optical fibres. This method of construction ensured the secrecy of the sign when not in operation and provided a readable message even in bright sunlight. At night, the intensity of the light from the sign was reduced to avoid glare. The height of the letters of the message was 150 mm, which was greater than would be required for a fixed sign beside a road with similar vehicle speeds and sight distances. This greater size was chosen to add impact to the sign, especially as drivers had to notice and read it quickly before they had passed it.

During the course of the experiment, a brief opinion survey of various sign messages revealed a preference for a sign which emphasised speed advice. In August 1980, the sign message was altered to read SLOW DOWN 30 (Plate 3) at the Meon Valley sites and SLOW DOWN 45 at Middle Wallop. The height of the figures was made 200 mm and the height of the letters in SLOW DOWN reduced to 100 mm. 30 mile/h (48 km/h) was chosen as the advised speed for West Meon and Droxford as all signs were within 30 mile/h (48 km/h) speed limit zones. The choice of a suitable advisory speed at Middle Wallop was more difficult as the only speed limit in force was the national one of 60 mile/h (97 km/h) for a single-carriageway road. 40 mile/h (64 km/h) was considered too

low for this fast straight road and two-thirds of drivers already exceeded this speed. 50 mile/h (80 km/h – also the trigger speed of the sign – see Section 2.2 and Table 1) was only exceeded by 20 per cent of drivers, but would be a desirable maximum past the Army base. 45 mile/h (72 km/h) was chosen so that drivers who only just triggered the sign would be advised to reduce their speed by at least 5 mile/h (8 km/h).

2.2 Sign trigger speeds and sensor installations

It was thought that, if the sign was switched on for too large a proportion of drivers, its effect would be devalued. If drivers recognise the sign to be giving advice only to those who need it, then they may pay more attention to it than they do to fixed speed limit signs. Therefore its operation was limited to the fastest one-third of drivers, who may be those more likely to be involved in accidents. At each site, radar speed measurements were made and the 67th percentile speed calculated. The electronic equipment which controlled the sign only allowed the trigger speed to be set at 10 km/h intervals. The two trigger speed settings which bracketed the 67th percentile speed were examined and the percentile speeds which they represented calculated. The speed setting chosen was that whose percentile was closest to 67.

The sign to sensors distance was set to be equivalent to the distance travelled in three seconds at the 85th percentile speed (Fig 1). The time of three seconds was decided on because Moore and Christie (1963) found that almost all drivers (99.9 per cent) should be able to read a sign consisting of N words in N/3 + 2 seconds. This formula was derived from an experiment in which subjects had to identify a specific place name on a sign displaying a number of unrelated names. In the case of the Speed Warning sign, the message is a meaningful phrase which would probably be read more quickly than a series of unrelated words. Against that however, it is possible that letters formed from a matrix of spots of light might be more difficult to read than the conventional sign alphabet. Three seconds at the 85th percentile speed was chosen to be a good compromise between these factors and the intention that the sign message should not be seen by too many drivers.

Details of the trigger speeds, percentiles which these represent, and positions of the signs and sensors are given in Table 1.

TABLE 1

Details of sign installations

Site	Trigger speed		Distance from speed limit boundary to sensors (metres)	Distance from sensors to sign (metres)
	km/h	Percentile		
West Meon (southbound)	70	80	30	60
West Meon (northbound)	60	75	–20 *	54
Droxford	60	77	5	52
Middle Wallop	80	81	–	70

* These sensors were 20 metres outside the 30 mile/h (48 km/h) zone.
All signs and other sensors, except Middle Wallop, were within 30 mile/h (48 km/h) zones.

3. EXPERIMENTAL DESIGN

The effects of the signs were evaluated in two ways, by measuring vehicle speeds at the sign sites and in the centre of the villages at various times before and after installation, and also by comparing injury accident records over a period before and after installation of the signs. Three control sites were chosen to make allowance for general area-wide speed changes due not to the sign but to such things as petrol price increases. These sites were chosen because they were physically similar to the sign sites and were also sites with similar accident histories.

The control sites for West Meon and Droxford were in the villages of King's Somborne (A3057) and Hurstbourne Tarrant (A343). Control data for Middle Wallop was collected on the A31 near Ropley, where the village centre is away from the A31, but where some development has occurred along the A31 in the vicinity of the village.

The speeds of vehicles were measured using hand-held radar guns. At West Meon and Droxford, these measurements were made at the centres of the villages and at the loop detectors for the signs. Measurements were made for both directions of travel at West Meon and northbound vehicles only at Droxford. Measurements at Middle Wallop were made at the detector and a point 440 metres beyond the sign, near a married quarters area of the Army base. At Ropley, speeds were measured for both directions of travel approximately in the middle of the developed area. At the control site at King's Somborne, measurements were made in the centre of the village for both directions of travel, (a suitable position on the outskirts of the village for one of the measurement points was not available). Hurstbourne Tarrant measurements were made on the outskirts of and in the village centre for southbound vehicles only.

Measurements were made at each site for a complete day from 08.00 to 18.00 hours. Only the speeds of unimpeded vehicles (platoon leaders or isolated vehicles) were measured and each vehicle was classified as light or heavy (under or over three tonnes unladen weight). In some instances it was possible to identify the same vehicle at both sign site and village centre and these results are presented separately.

Measurements were made for several weeks before and after the signs were commissioned and at quarterly intervals up to twelve months. At a particular site, measurements were always made on the same day of the week and these are listed in Table 2.

TABLE 2

Measurement days and distances between sign and village measurement points

Test sites	Measurement day	Distance from sign to village centre measurement point (metres)
West Meon (southbound)	Monday	310
West Meon (northbound)	Tuesday	140
Droxford (northbound)	Wednesday	340
Middle Wallop (southbound)	Thursday	440
Control sites	Measurement day	
Ropley	Tuesday	
Hurstbourne Tarrant	Wednesday	
King's Somborne	Thursday	

Measurements at experimental sign sites were made in the 4th, 3rd, and 1st week before sign installation and in the 1st, 4th, 13th, 26th, 39th, and 52nd week after. Measurements at the control sites were made in the week before those at the sign villages, with an additional set of measurements in the second week after installation and no measurements in the fourth week before installation (measurements were made at the sign sites in this week).

The measurements were grouped into three phases: 'Before', 'After 1' (message in use 'SLOW DOWN PLEASE' – up to 9 months after), and 'After 2' (message in use 'SLOW DOWN 30' at West Meon and Droxford and 'SLOW DOWN 45' at Middle Wallop – 12 months after).

The signs in the Meon Valley were commissioned on Monday 17th September 1979 and that at Middle Wallop on Tuesday 18th September 1979.

Injury accident data were examined for the period from four years before the signs were installed to four years after. Injury accidents are considered, as these are more reliably reported to the Police than accidents in which there is only damage to vehicles or property. The length of road studied at each site was about one kilometre, with some variation between sites. At any one site the same length of road was considered throughout the analysis period. At West Meon, Droxford, King's Somborne and Hurstbourne Tarrant this length was the 30 mile/h (48 km/h) speed limit zone. At Middle Wallop, it was from the sign to a point 1.3 km beyond which represented the end of the Army "village", with a similar length being chosen at Ropley.

4. RESULTS AND DISCUSSION

The results are presented in summary form for each test and control site in Figures 2 to 10. The data for light and heavy vehicles are presented separately. Each Figure contains measurements made at the sign and in the village (or equivalent position) analysed as mean speeds, 85th percentile speeds and percentage of vehicles exceeding a specified speed.

Changes which occur in the villages should show any direct effect of the operation of the sign. Measurements at the sign will indicate an effect of the presence of the sign (mainly a learning effect for regular users of the road), rather than any effect on individuals who activate it.

Speed measurements were not made when rain was falling steadily. Weather conditions were recorded hourly and the proportion of dry days to days with some showers was found to be approximately the same for both sign and control sites for each measurement period.

4.1 Meon Valley village sites

4.1.1 Measurements in the villages. The Meon Valley village centre data (Figs 2–4) should be compared with the Hurstbourne Tarrant village centre results (Fig 8) together with both sets of village centre measurements at King's Somborne (Figs 9 and 10). The results both before and after the signs were brought into operation are very similar. The mean speeds of light and heavy vehicles for each measurement day fluctuate and indicate a very small overall reduction at both test and control sites in the After 1 period. These reductions are of similar magnitude at test and control villages and are small compared with the general fluctuations between measurement days. It is therefore unlikely that the changes found at test villages are to any appreciable degree due to the operation of the sign.

There is little evidence in the data that the amended sign message (After 2) is more effective than the original. However, the amended message is preferred as it gives more positive advice to the driver and conforms with other forms of advisory speed signs which suggest a specific maximum speed (for example motorway matrix signs, road works and bend warning signs).

As all vehicles approaching the sign above the 85th percentile speed will trigger it, the 85th percentile speed in the villages was expected to be a more sensitive measure of any useful changes brought about by the sign. However, the measured changes were very small. No consistent effect of the sign on 85th percentile speeds could be discerned for either light or heavy vehicles with either of the two sign messages.

The third method of analysis employed was to consider the percentage of vehicles exceeding the 30 mile/h (48 km/h) speed limit in the villages. The tight bends at West Meon (experimental site) and Hurstbourne Tarrant (control) effectively prevented most vehicles from exceeding the speed limit in the villages; the proportion of those which did so, changed very little when the sign was brought into use or the message amended. The villages of Droxford (experimental) and King's Somborne (control) showed reductions in the percentage of both light and heavy vehicles exceeding 48 km/h in the After 1 and After 2 periods.

4.1.2 Measurements at the sign. The data relevant as a control for speed measurements at the signs at West Meon and Droxford are those for the equivalent site at Hurstbourne Tarrant. These data were reasonably consistent throughout the Before, After 1 and After 2 periods for both light and heavy vehicles. The most interesting feature of the data at the three signs was a noticeable downwards trend with time in the After results. This trend was apparent for both light and heavy vehicles, at all three signs and in whichever measure is considered (mean, 85th percentile, percentage exceeding 48 km/h). As the speed measurements were made at the point at which the sign triggered, drivers cannot be reacting to the message, only to the presence of the sign. This implies that at least some of the regular users of the road are adapting their behaviour and slowing down before arriving at the sign to avoid triggering it.

4.1.3 Behaviour and speeds of drivers who trigger the sign. A more direct effect of the operation of the sign has been observed from drivers' behaviour immediately after they have caused it to operate. When the experiment was planned, resources were not available to take measurements at this point, but casual observations have indicated that drivers who trigger the sign do slow down, many of them by braking. That there is not a greater transfer of this effect to the village centres may be due to the bends on the approach to each village. Regardless of the specific advice given by the sign, the direction of that advice to a particular driver may cause him to be more alert and attentive to the situation ahead on the road and perhaps to appreciate the situation as more hazardous than he would previously have done. Even if the effect does not last very long, it may be sufficient to enable him to safely negotiate the hazard. If this hypothesis is correct, it might help to account for the reduction in accidents (Section 4.3) at West Meon and Droxford, despite the lack of an appreciable reduction in vehicle speeds.

At Droxford, the registration numbers of the light vehicles whose speeds were measured were recorded when the work load permitted. Comparison of registration numbers at the sign and in the village enables the same vehicle to be identified at both sites. Table 3 shows the mean speeds at the sign and in the village of identified vehicles which exceeded the sign trigger speed of 60 km/h.

The overall mean speeds of identified vehicles travelling at more than 60 km/h at the sign in the Before, After 1 and After 2 periods are not significantly different from one another. This was to be expected as, although there may be fewer vehicles travelling at above 60 km/h in the After periods, the mean speed of these vehicles is likely to be similar to what it was before.

When the sign is operating a reduction of speeds in the centre of the village might be expected for those vehicles exceeding 60 km/h at the sign. A small reduction in speed of about 2 km/h was found, indicating that the sign was having a slight effect on the higher speed vehicles.

The mean of the speed reduction between the sign and the village increased slightly (an improvement) when the sign was in operation.

TABLE 3

Speed changes of identified light vehicles exceeding triggering sign speed at Droxford (km/h)

	Mean speed (sign)	Standard deviation of speed at sign	Mean speed (village)	Standard deviation of speed in village	Mean of the speed reduction	Standard deviation of speed reduction	Sample Size
4 weeks before	69.8	7.4	51.2	5.8	18.6	7.9	183
1 week before	69.2	7.4	50.7	6.2	18.5	7.1	183
Overall Before	69.5	7.4	51.0	6.0	18.5	7.5	366
1 week after	69.7	8.7	48.6	7.0	21.1	9.9	97
4 weeks after	70.7	8.9	49.6	6.2	21.1	9.5	126
3 months after	67.1	5.6	47.1	5.2	20.0	6.5	70
6 months after	66.9	5.2	48.6	6.2	18.3	7.3	54
9 months after	68.2	6.5	52.4	3.4	15.8	7.9	66
Overall After 1	69.0	7.7	49.2	6.1	19.7	8.8	413
After 2 (12 months after)	67.8	5.9	47.1	4.9	20.7	7.6	55

4.2 Middle Wallop site

The use of the sign at Middle Wallop was to test it in different circumstances from the 30 mile/h (48 km/h) speed-restricted villages in the Meon Valley. At Middle Wallop, there was not a clearly defined village, and only the national 60 mile/h (97 km/h) speed limit for single-carriageway roads applied. In the After 2 period, drivers were advised by the sign to choose a speed (45 mile/h – 72 km/h), well below this national limit.

The speed of vehicles was measured 440 metres from the sign, not far from the entrance to an Army base. No differences in mean speeds were apparent between the Before and After 1 data for either light or heavy vehicles (Fig 5).

Mean speeds at the control site of Ropley (Figs 6 and 7) were also very consistent during the Before and After 1 periods. At Middle Wallop and Ropley, the overall mean speed in After 2 was slightly higher than in After 1, but the changes were comparable with the variations between individual measurement days.

At the sign, the mean speeds of both light and heavy vehicles remained consistent throughout the various phases of the experiment.

No evidence of an effect of the sign could be discerned in the 85th percentile speed data or in the percentage of vehicles exceeding 72 km/h (45 mile/h – the advisory speed of the amended sign message).

Thus, at Middle Wallop, the sign does not appear to have been effective in reducing vehicle speeds. The road after the sign is straight and slightly downhill. Even if the sign alerts a driver, it is possible that he would not perceive the road situation before him as hazardous and he therefore decides, perhaps subconsciously, that its advice is not relevant to him. A different sign message drawing attention to the potential hazard ahead might have had a greater effect.

4.3 Accidents

For each site, a computer print-out was obtained from which information was abstracted on all injury accidents. The same length of road was always considered for any one site and these are listed in Table 4. The period covered was four years before and four years after the signs were commissioned.

Empirical logarithmic transforms of the Before and After data in Table 4 were analysed by normal statistical methods (Appendix 1). The transform used was ln [ai/bi], where ai, bi were respectively the after and before accident data for site i. If either ai or bi was zero then 0.5 was added to both before and after data to avoid the anomaly caused by including logarithms of zero or infinity.

The data indicate that at sites similar to West Meon and Droxford an overall reduction of accidents of 52 per cent might be expected. This reduction is not statistically significant. Figure 11 illustrates the skewed nature of the distribution of possible expected results. It shows that, on the basis of the limited existing data, there is a 0.77 probability that accidents would be reduced overall if signs were installed at sites similar to West Meon and Droxford and a 0.9 probability that the overall change in accidents resulting from installing these signs would lie between a 136 per cent increase and a 90 per cent decrease. These limits are very wide because of the relatively small number of accidents recorded in the experiment.

This result is encouraging but is based on a relatively small amount of data. It was also not possible to check that the level of vehicle flow in the various villages had remained constant throughout the period in question, although it is thought very unlikely that any significant changes in flow occurred. Moreover, the test sites were not chosen at random, but were treated because of their poor accident record. A reduction in accidents might well be expected, because of regression to the mean (Helliar-Symons, 1981). However, the same argument may be applied to the control villages, which were also chosen because of their poor accident record.

At Middle Wallop, there has not been a change in the level of accidents. During the four years before sign installation there were five accidents and during the succeeding four years there were also five. At Ropley, where speeds were similar, the corresponding accident numbers were eleven and eight.

The cost of purchasing and installing an automatic sign of this type will vary from site to site, particularly in the cost of provision of an electricity supply. £6000 is thought to be a typical figure. A sign should have a life of about ten years. Maintenance costs have proved to be low for these devices. One man-day per year per sign is probably a generous allowance for cleaning, bulb replacement and occasional repair. Thus only one serious injury or six slight injury accidents need be saved (at June 1982 values) during the life of the sign for its use to be cost-beneficial.

TABLE 4

Injury accidents

	Length of road studied	Accident numbers for each year							
		Before				After			
		Sep 75– Sep 76	Sep 76– Sep 77	Sep 77– Sep 78	Sep 78– Sep 79	Sep 79– Sep 80	Sep 80– Sep 81	Sep 81– Sep 82	Sep 82– Sep 83
TEST SITES									
West Meon	0.7 km	2	2	3	0	0	1	2	1
Droxford	0.9 km	2	4	1	4	0	0	0	0
Middle Wallop	1.3 km	0	2	2	1	1	3	1	0
CONTROL SITES									
H. Tarrant	1.0 km	1	0	1	1	0	1	1	1
King's Somb.	2.0 km	2	0	5	3	1	1	2	1
Ropley	1.2 km	2	4	3	2	3	0	3	2

5. CONCLUSIONS

In the village centres of West Meon and Droxford, the signs appear to have only produced a very slight reduction in the speeds of the higher speed vehicles.

The measured speeds at the signs at both West Meon and Droxford tended to decrease with time after the signs were installed. This could be explained by some regular users of the road learning to reduce their approach speed to avoid triggering the sign.

The analysis indicated a non-significant reduction in accidents of 52 per cent at West Meon and Droxford associated with the use of the signs. The 90 per cent confidence interval for this result is from 136 per cent increase to 90 per cent decrease.

The sign did not appear to have a useful effect on the unrestricted A343 at Middle Wallop.

The electronic equipment which triggered the sign could only be set to multiples of 10 km/h. Multiples of 5 km/h would allow trigger levels to be chosen which better match the 67th percentile speed.

6. ACKNOWLEDGEMENTS

The work described in this report was carried out in the Road User Characteristics Division of the Safety Department of TRRL.

The authors would like to thank Messrs D Selby and M Noyce of Hampshire County Council for their considerable assistance with this experiment.

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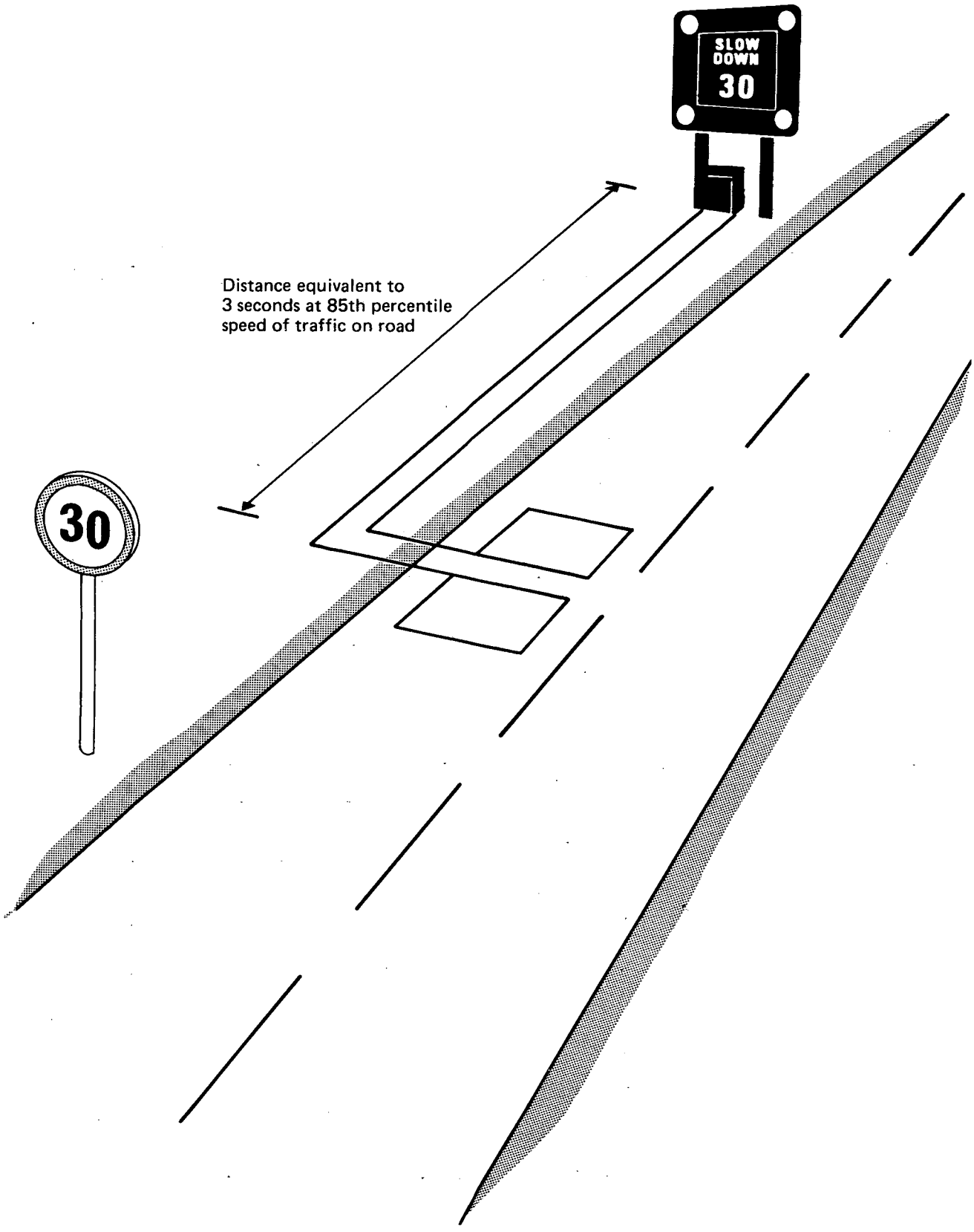
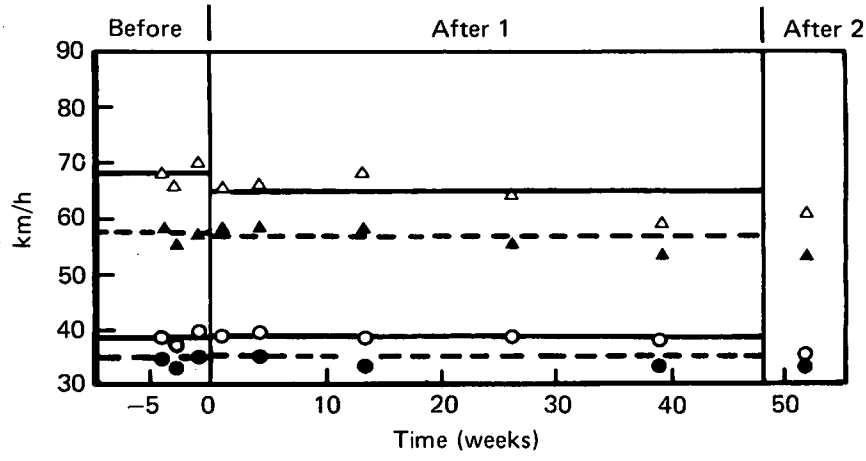
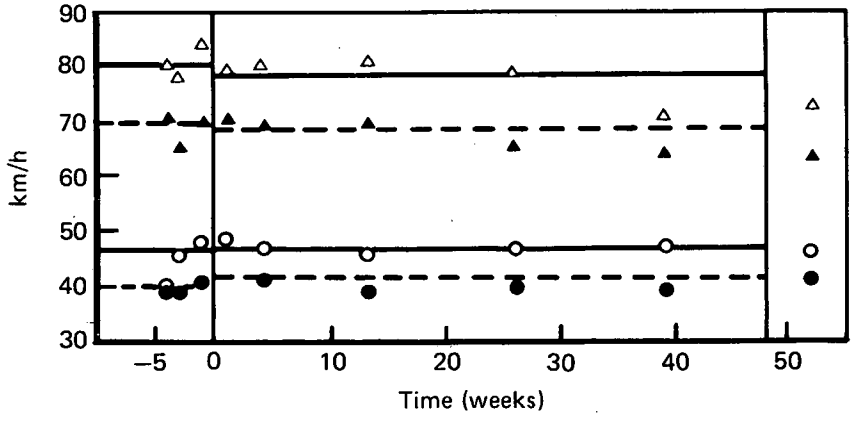


Fig. 1 Layout of typical site

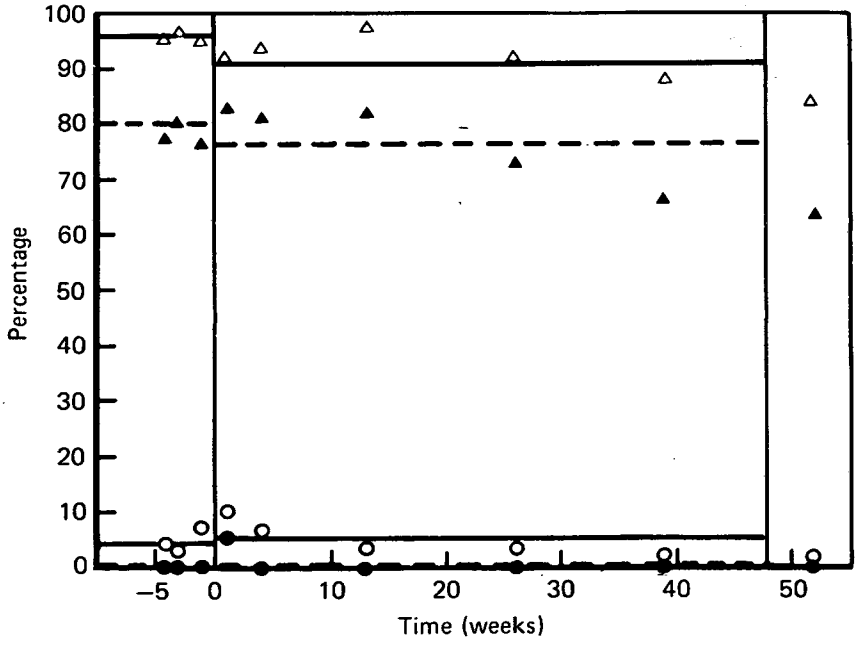
Mean speeds



85th percentile speeds



Percentage of vehicles exceeding 48km/h



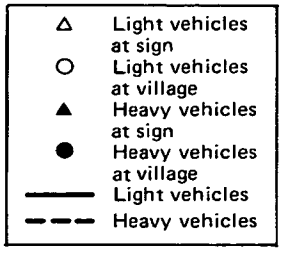


Fig. 2 West Meon, Southbound (Test site)

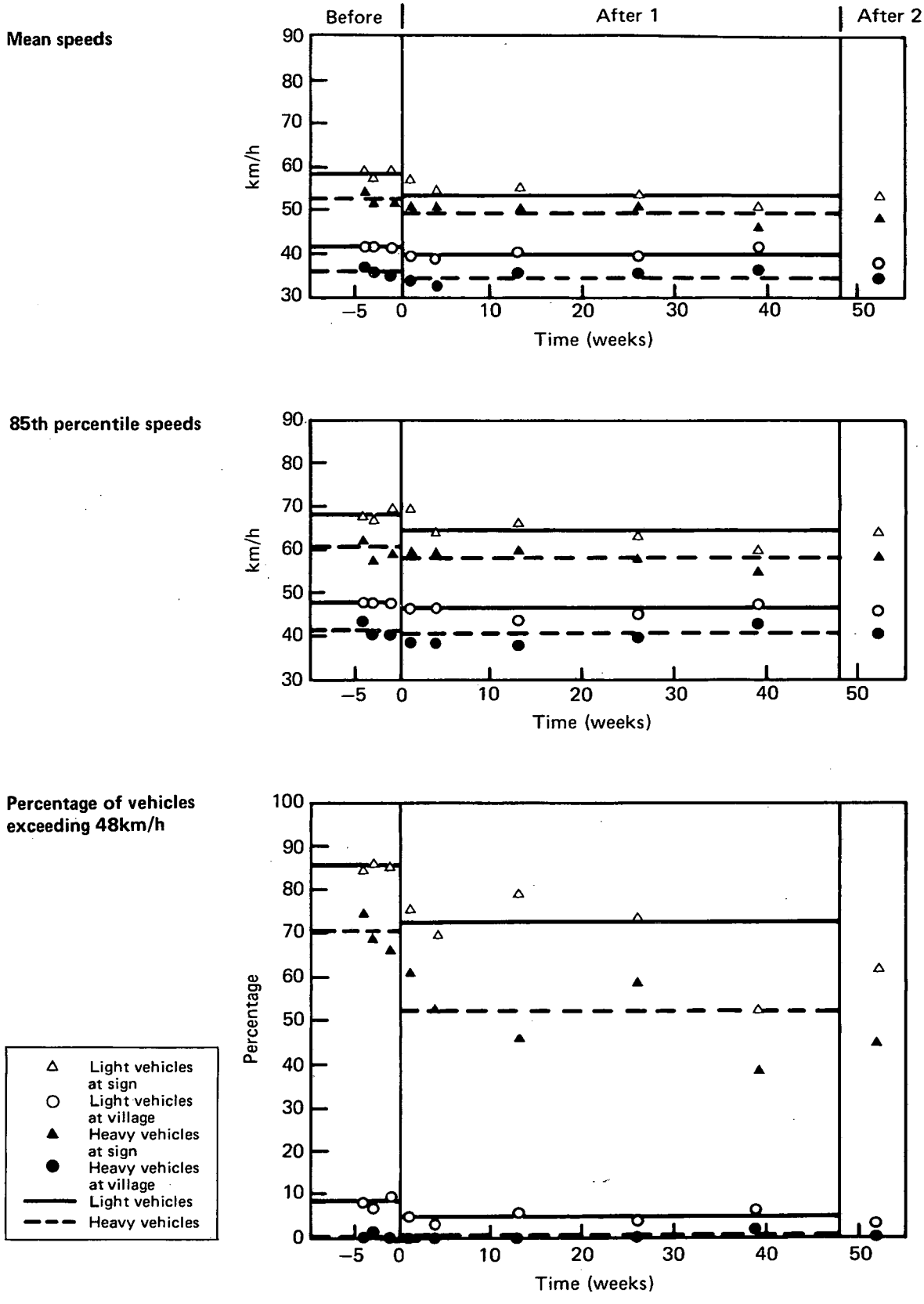
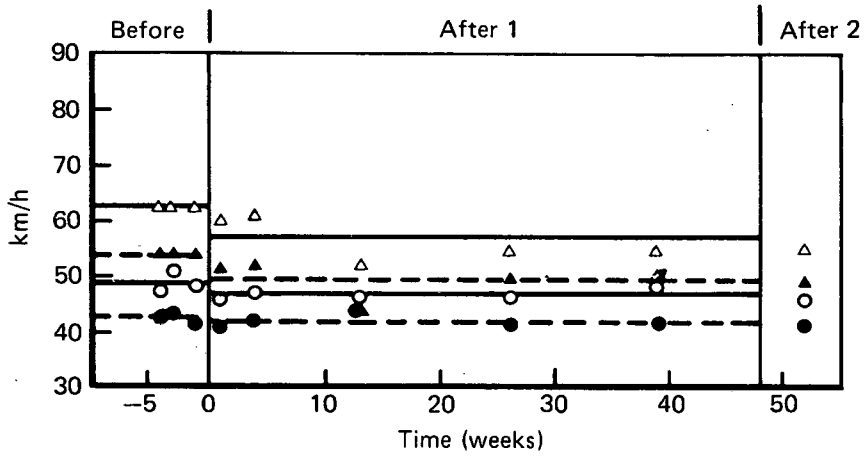
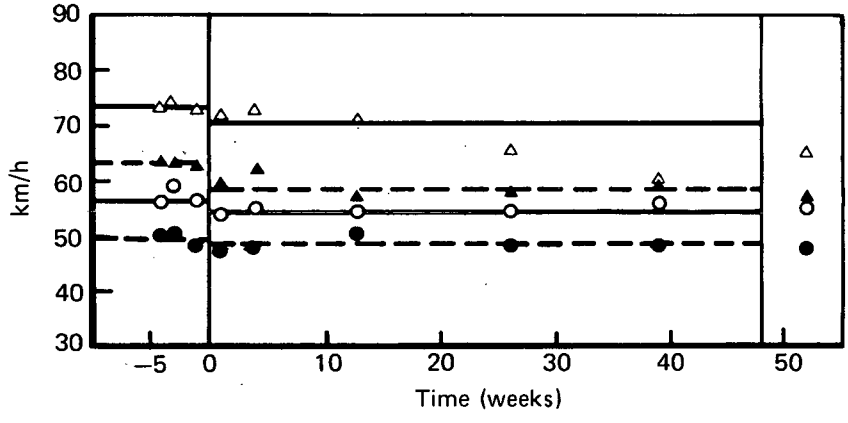


Fig. 3 West Meon, Northbound (Test site)

Mean speeds



85th percentile speeds



Percentage of vehicles exceeding 48km/h

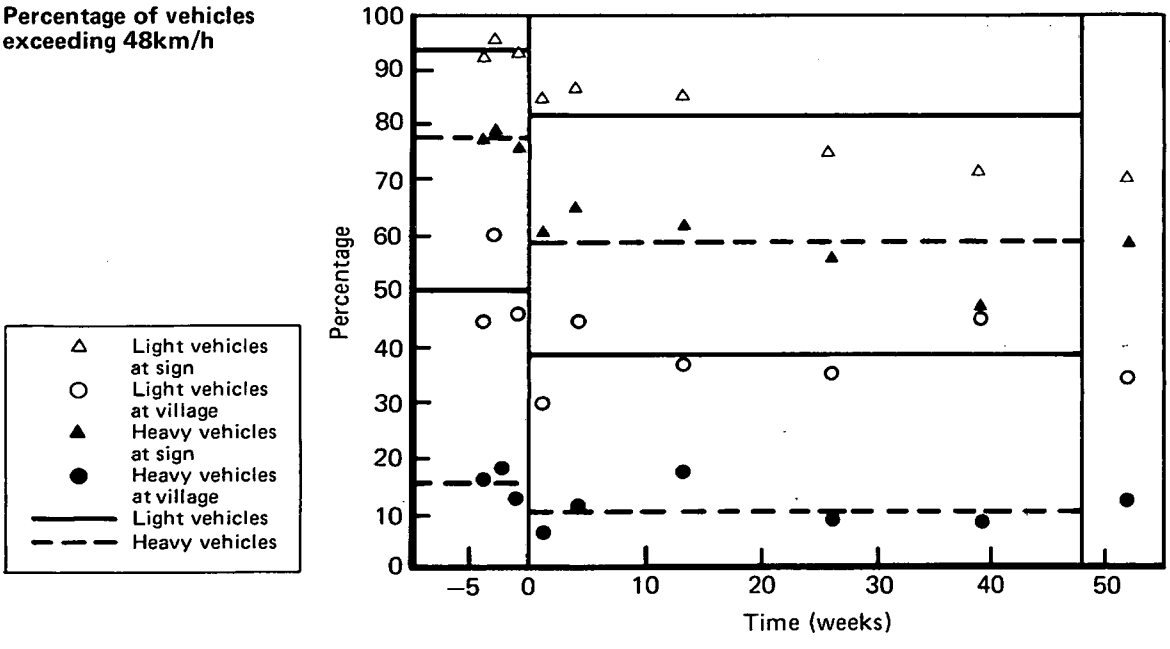
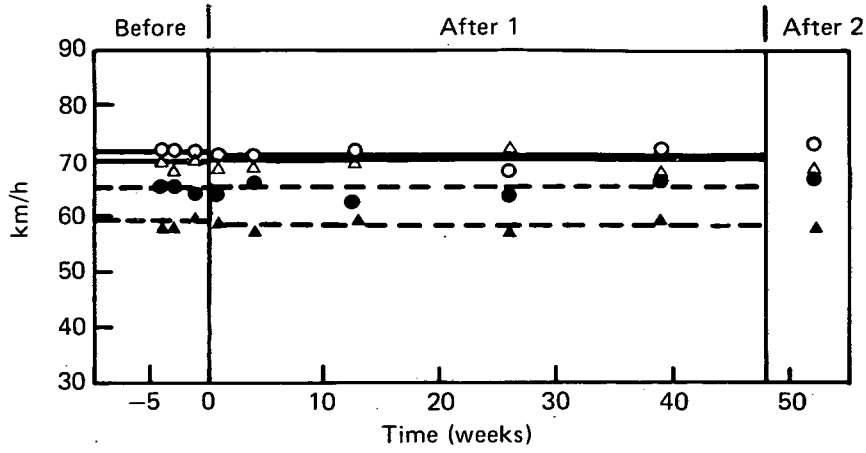
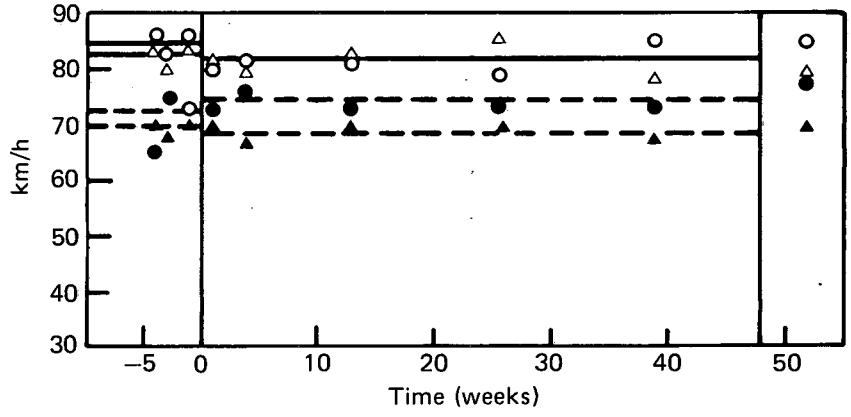


Fig. 4 Droxford (Test site)

Mean speeds



85th percentile speeds



Percentage of vehicles exceeding 72km/h

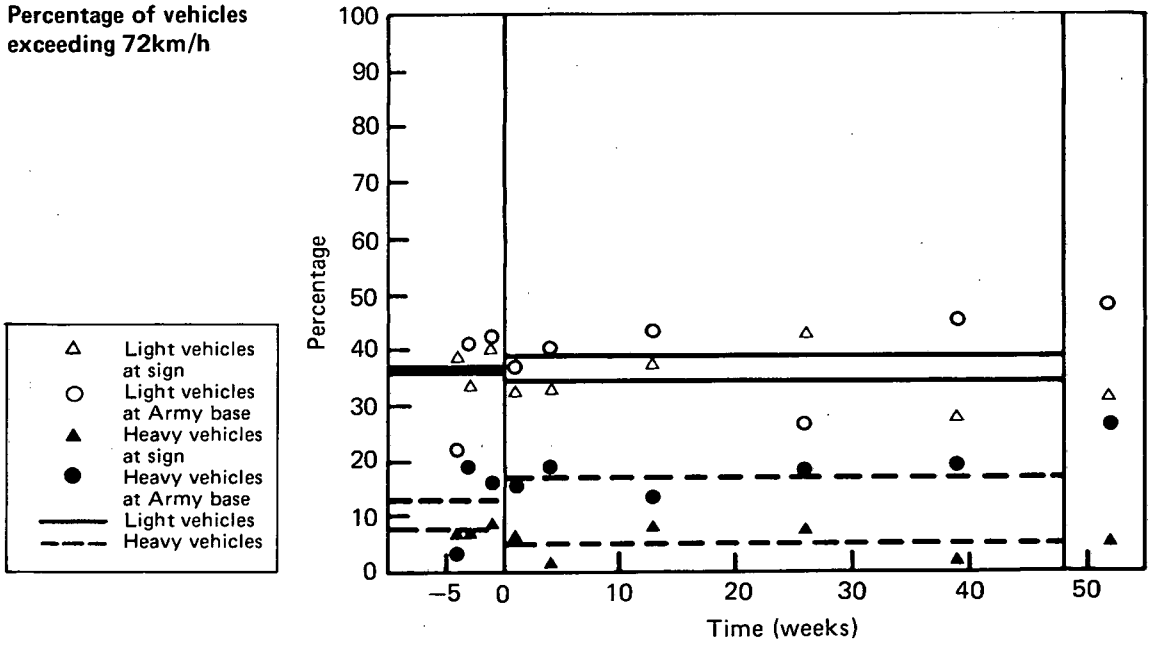


Fig. 5 Middle Wallop (Test site)

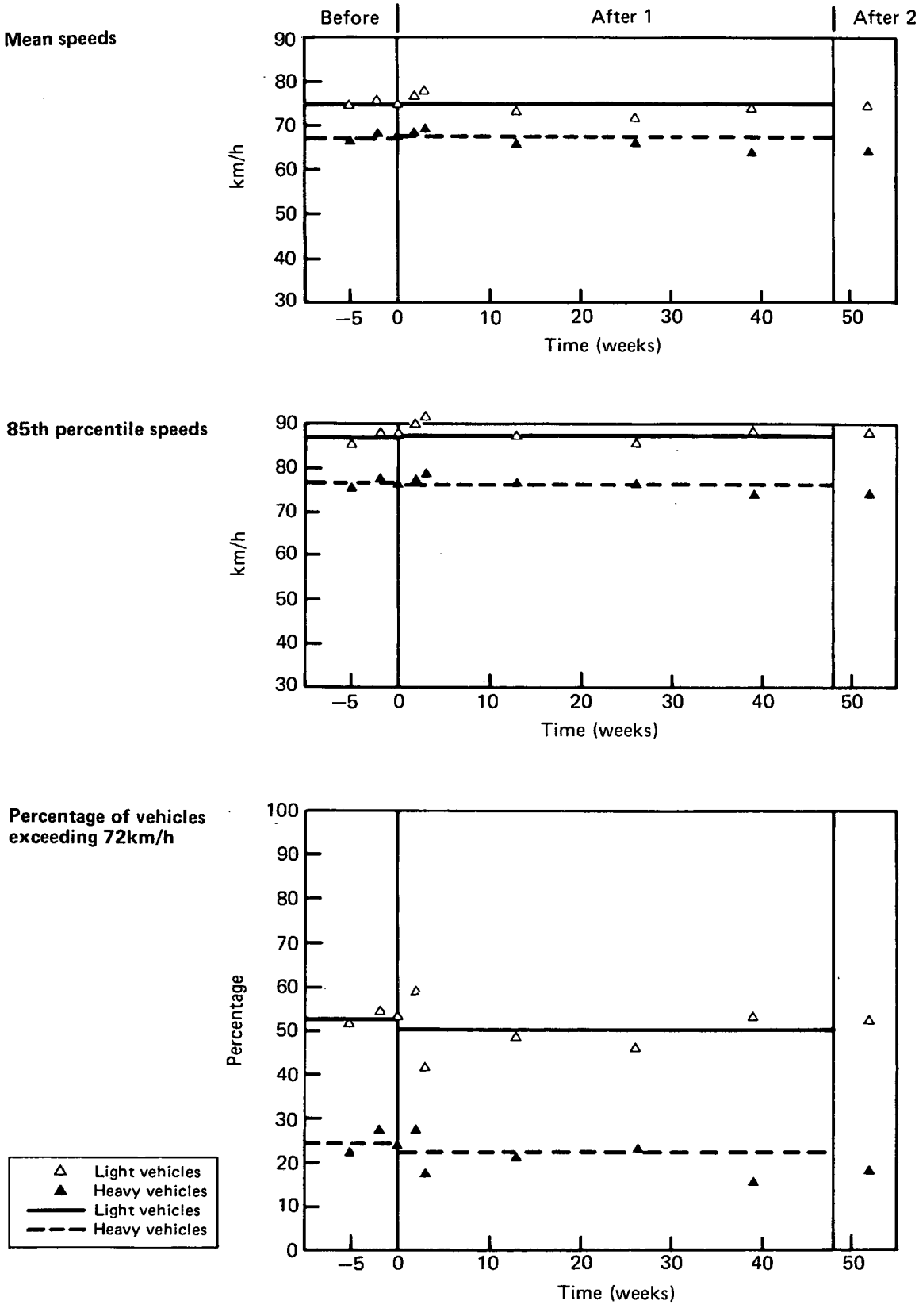


Fig. 6 Ropley, Westbound (Control site)

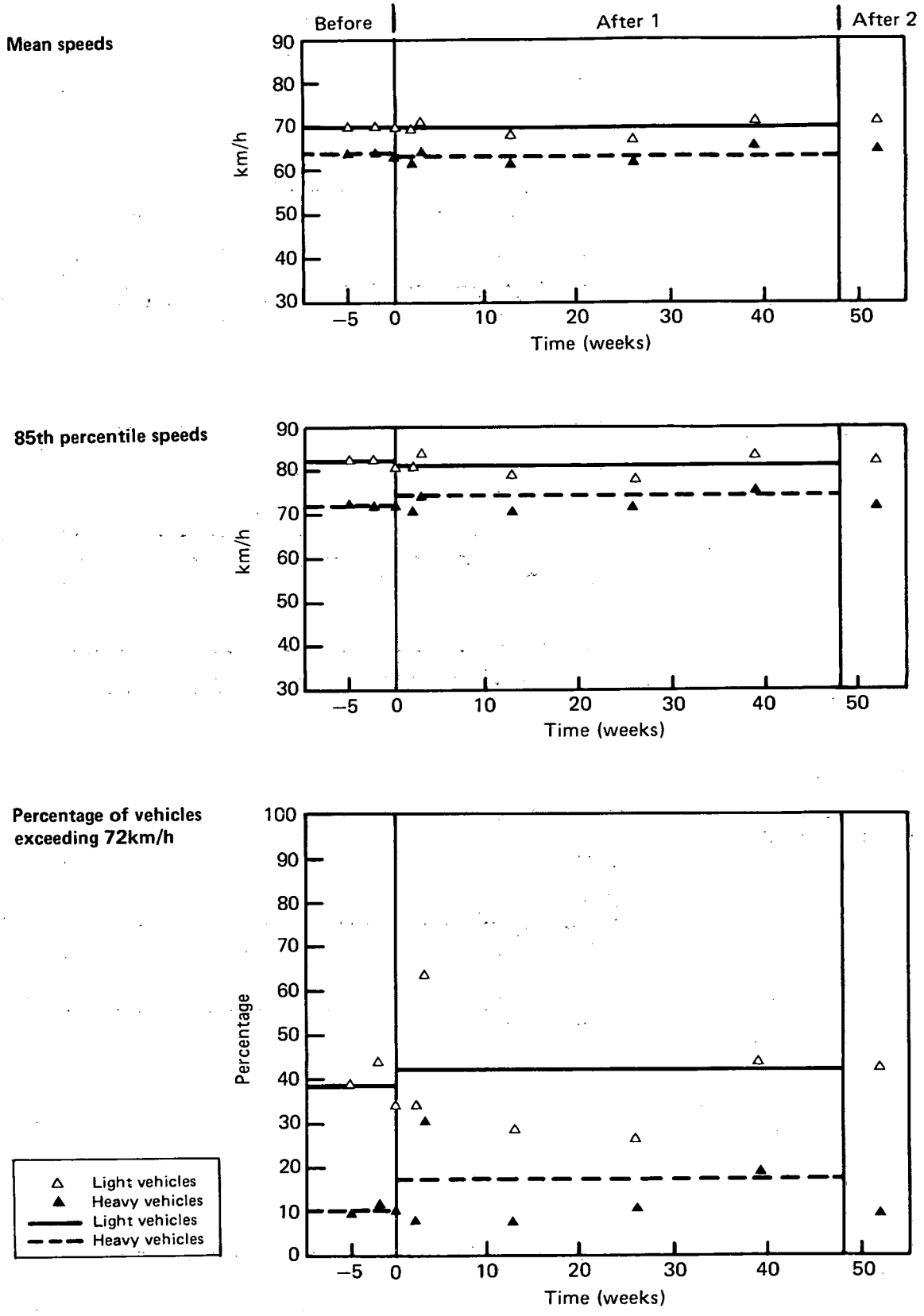
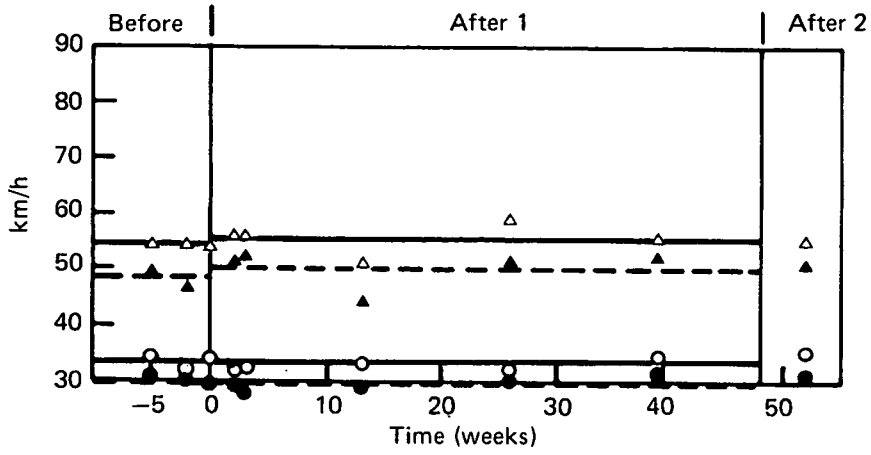
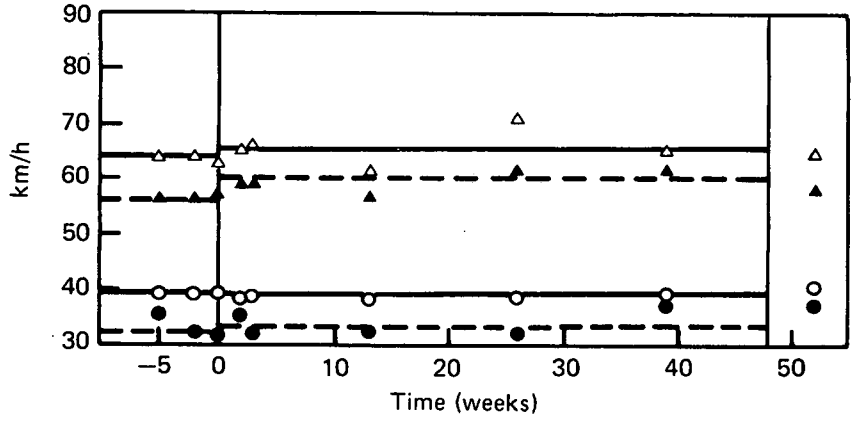


Fig. 7 Ropley, Eastbound (Control site)

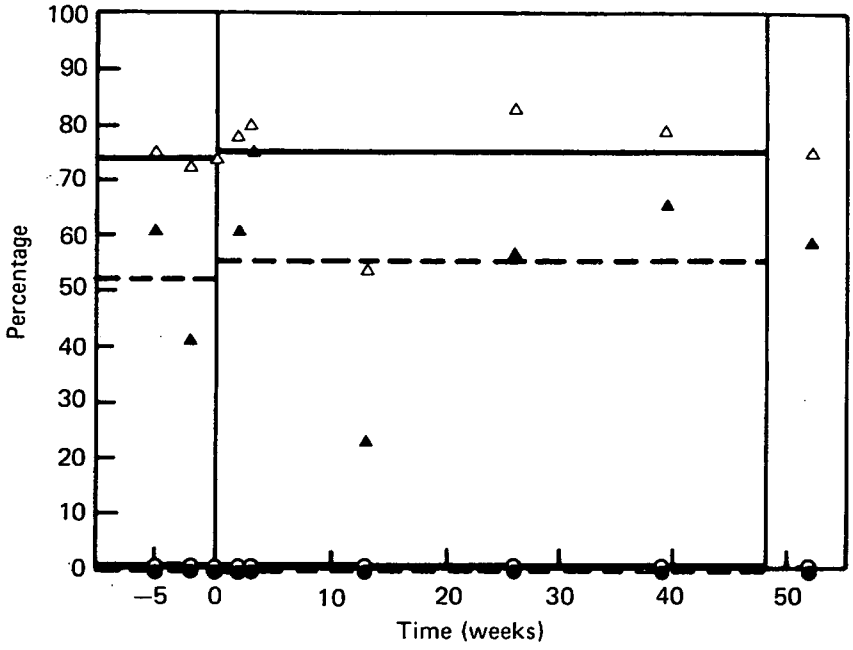
Mean speeds



85th percentile speeds



Percentage of vehicles exceeding 48km/h



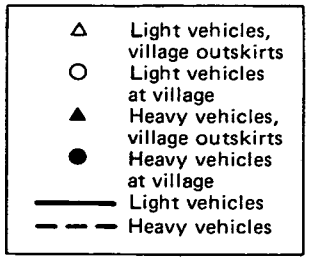


Fig. 8 Hurstbourne Tarrant (Control site)

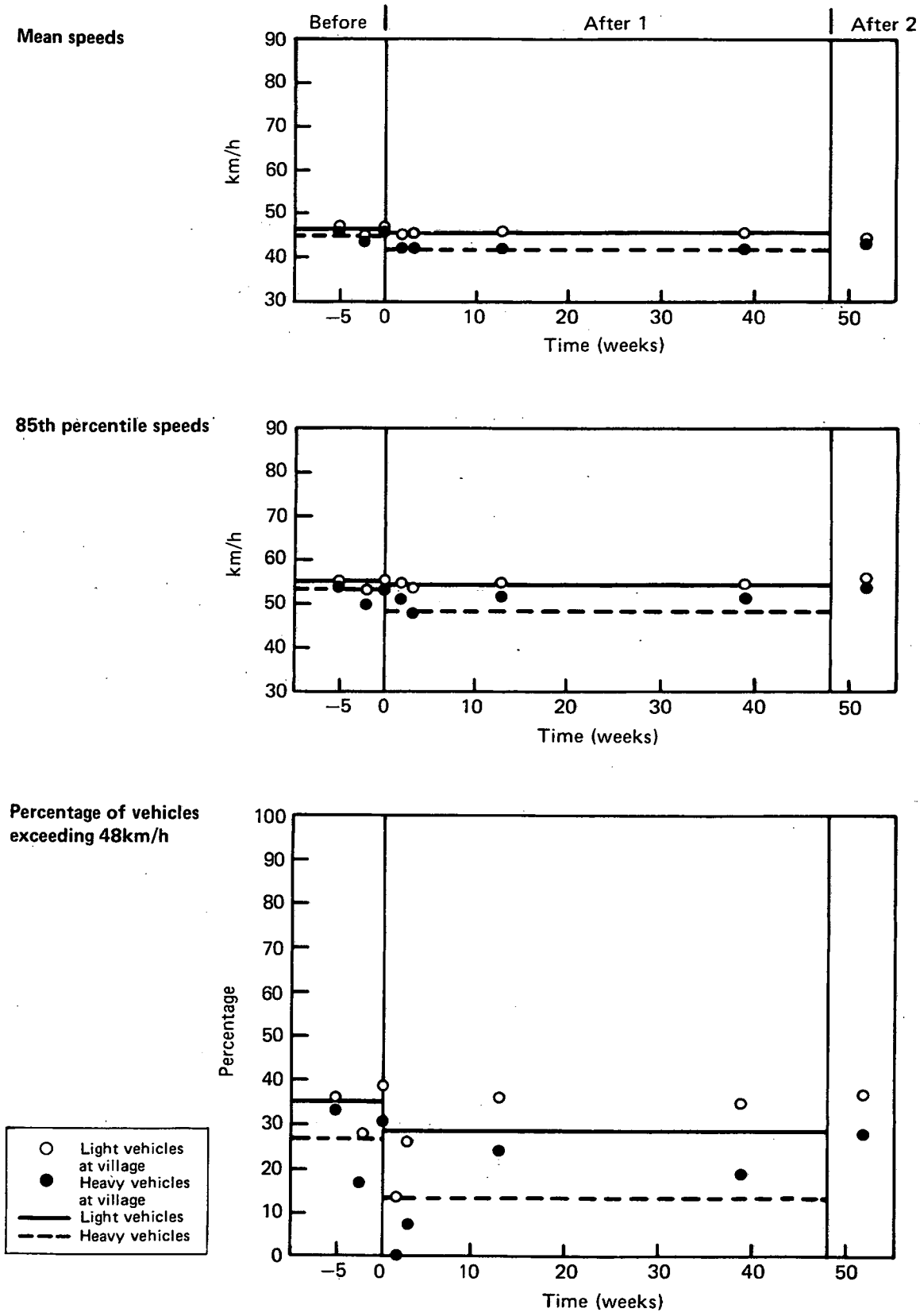


Fig. 9 King's Somborne, Northbound (Control site)

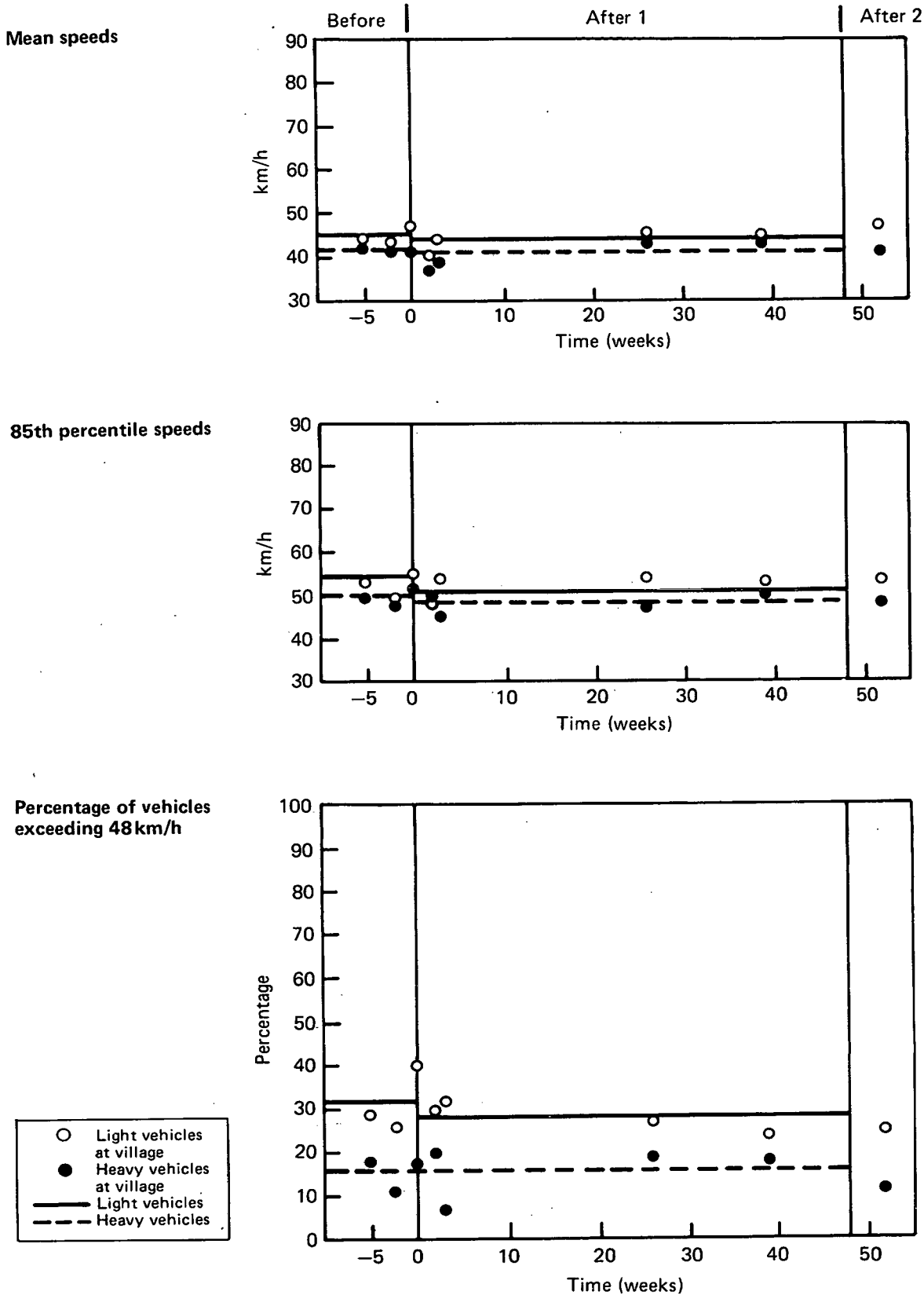
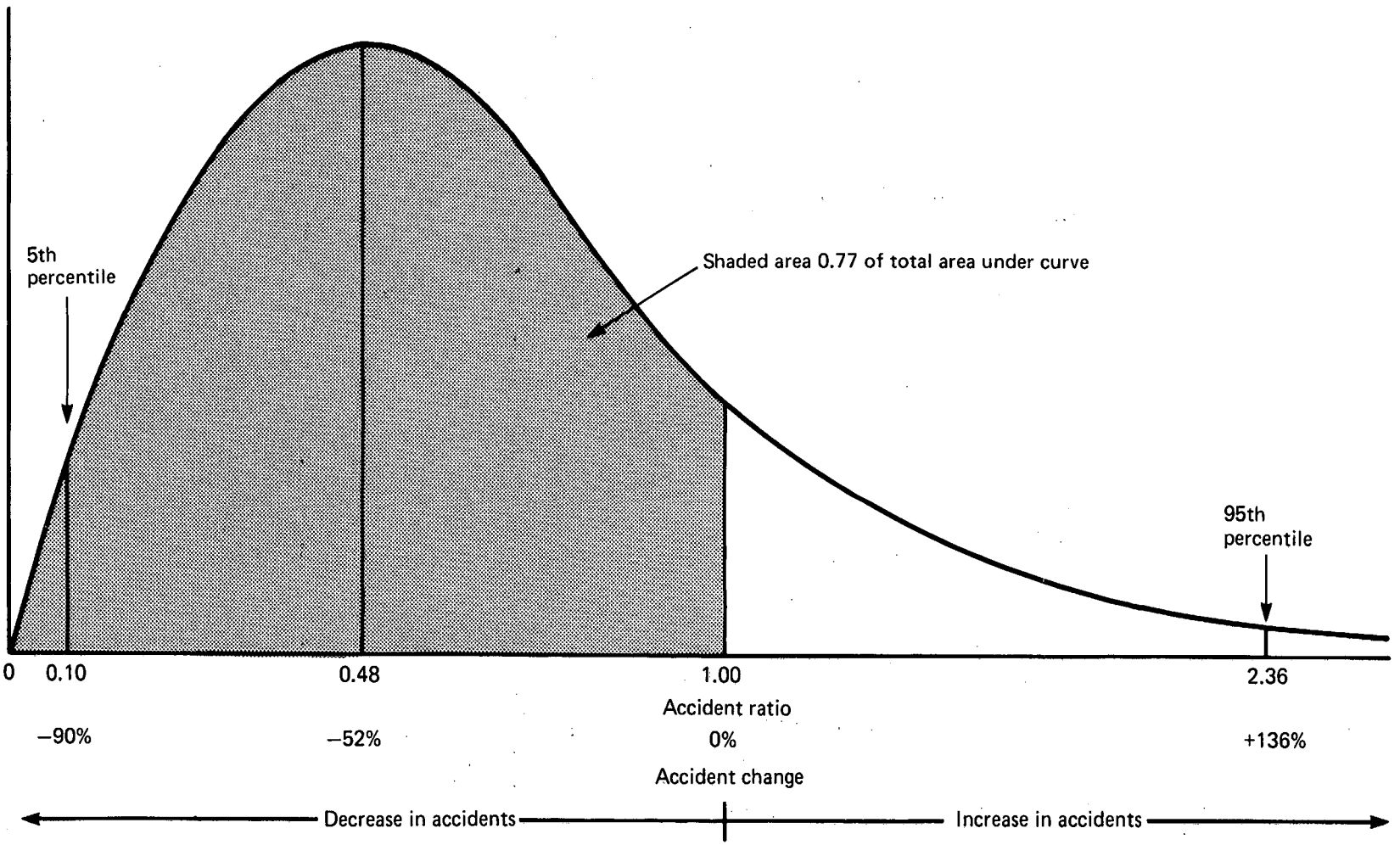


Fig. 10 King's Somborne, Southbound (Control site)



The area under the curve between any two accident ratios is the confidence that the true result lies in that range
The accident ratio is exp (λ(diff)) of Appendix I A ratio of 1.00 indicates no change

Fig. 11 Confidence distribution of the accident ratio

Neg. no. R851/79/1

Plate 1 The speed warning sign at Middle Wallop when not activated

Neg. no. R851/79/2

Plate 2 The speed warning sign at Middle Wallop displaying the original message

Neg. no. R705/81/4

Plate 3 The speed warning sign at West Meon (northbound) displaying the amended message

8. APPENDIX I

COMPARISON OF CHANGES IN ACCIDENT FREQUENCY IN TEST AND CONTROL GROUPS

BY P P SCOTT

Many trials of safety devices are similar to those described in this report. In such trials before and after accident data are collected at a group of sites, some of which are control sites and some of which are experimental sites. Better use of the information in the data can be made than simply to gather together all before and after data at control and experimental sites into a 2x2 contingency table and perform a χ^2 test on the result.

At any single site, experimental or control, the proportional change in accident frequency is given by $r = a/b$, where a and b represent the accident frequencies in the after and before periods respectively.

For any given underlying proportional change, sample values of r can vary considerably due to the inherently high variability of the accident frequencies a and b. The distribution of r values obtained from many samples would be highly skewed. For situations with little or no change, r would be expected to be approximately one. It could vary downwards as far as zero, but there is no upper limit to its possible values. The logarithm of a variable such as r is usually found to have a more symmetrical distribution, which makes it more amenable to standard statistical treatments. For this and other statistical reasons it is preferable to work with the natural logarithm of the after-to-before ratio when drawing inferences.

$$\lambda = \ln (a/b)$$

If either a or b is zero then 0.5 is added to both a and b in the above expression to avoid the difficulty that zero frequencies would otherwise present when taking logarithms.

The variance of λ is given by:

$$\text{var}(\lambda) = 1/(a+1) + 1/(b+1) = S^2$$

subject to a maximum value of one, ie $\text{var}(\lambda) = \min [1, 1/(a+1) + 1/(b+1)]$

For a group of m sites which have been treated, the average effect is given by:

$$\bar{\lambda}(tr) = \sum_{i=1}^{m} \frac{\lambda_i}{S_i^2} \Bigg/ \sum_{i=1}^{m} \frac{1}{S_i^2}$$

where the λ and S^2 are as defined above, and the subscript "i" is simply a "label" denoting the ith of the m sites.

Since individual λ_i are subject to uncertainty, expressed in the S_i^2, then so too is the estimate $\bar{\lambda}(tr)$. Its variance is given by:

$$V(tr) = \max [V_1, V_2]$$

where $$V_1 = 1 \Big/ \sum_{i=1}^{m} \frac{1}{S_i^2}$$

and $$V_2 = \sum_{i=1}^{m} \frac{1}{S_i^4} \times \sum_{i=1}^{m} \left[\frac{(\lambda_i - \bar{\lambda}(tr))^2}{S_i^2} \right] \Big/ \left(\sum_{i=1}^{m} \frac{1}{S_i^2} \right)^3$$

V_1 represents the random variability due to the uncertainty in the individual site estimates. V_2 gives an alternative estimate of this variability, but also includes a measure of the variability between sites of the "real" (long-term) before-to-after change; ie if $\lambda(tr)$ is regarded as an estimate of the change which would occur, on average, at all sites which might be given this type of safety treatment, then V_2 measures the uncertainty in $\bar{\lambda}(tr)$ due to having only a finite sample (m) of those possible sites. If a different sample of sites were used, then different λi, and hence a different $\bar{\lambda}(tr)$, would be found. If the changes are similar at all sample sites, then V_1 and V_2 should be approximately equal, though, by chance, V_2 may sometimes be smaller than V_1. In that case V_2 would give an unrealistically low estimate of the variance of $\bar{\lambda}(tr)$ so that the best estimate of var $(\bar{\lambda}(tr))$ is larger of V_1 and V_2.

If the question being asked is "is the treatment effective at *this* group of sites?", rather than "is the treatment effective in general, judged from these example sites?", then V_1 should be used. It is usually more useful to answer the second question as it indicates the confidence which could be placed in the effectiveness of the treatment if it were applied more widely. In this case the larger of V_1 and V_2 should be used.

The estimated average change at the control sites, $\bar{\lambda}(con)$, and its variance, v(con), can be calculated using formulae identical to those above, except that the summations are made over the n control sites instead of the m treated sites and $\bar{\lambda}(con)$ is substituted for $\bar{\lambda}(tr)$ in the expression for V_2.

The effect of the treatment can then be estimated by the difference between the average changes at the test sites and the control sites:

$$\lambda(diff) = \bar{\lambda}(tr) - \bar{\lambda}(con)$$

with variance given by:

$$V = V(tr) + V(con)$$

where V(tr) and V(con) are either V_1 for both test and control sites respectively or max $[V_1, V_2]$ for both.

Regarding $\lambda(diff)$ as a normally distributed variable with variance V, inferences may be drawn about the average effectiveness in terms of the best estimate, $\lambda(diff)$, and confidence intervals around it (or, alternatively, in terms of a significance test of its difference from zero).

The estimate λ(diff) and its standard error $\sqrt{V}$ are on the logarithmic scale. For presentation of results it may be advantageous to convert the best estimate and the confidence limits back to the scale of proportional differences via the exponential function = exp (λ(diff)). The amount by which this differs from one represents the average effectivness of the treatment; eg exp (λ(diff)) = 0.80 indicates a 20 per cent reduction in accident frequency at the treated sites relative to the control sites. Exp (λ(diff)) = 1.20 represents a 20 per cent increase.

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Speed reductions in the centres of the villages at West Meon and Droxford were very small, but some drivers appeared to be reacting to the presence of the signs by slowing down before reaching them. The data indicate an overall reduction in injury accidents of 52 per cent, although this result is not statistically significant. It may be that the signs alert drivers to be more attentive to the road ahead, even if they do not slow down.

At Middle Wallop, the sign did not have an effect on speeds and there was no change in injury accidents.

ISSN 0305–1293

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